

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of)

Jeffrey HUNG et al.)

Application No.: 09/002,007)

Filed: December 31, 1997)

For: ETCHING PROCESS FOR ORGANIC)
ANTI-REFLECTIVE COATING)

Group Art Unit: 1765

Examiner: L. Vinh

BRIEF FOR APPELLANT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

This appeal is from the decision of the examiner dated December 8, 2000 (Paper No. 20), finally rejecting Claims 1-13 and 16-22, which are reproduced as an Appendix to this brief.

The Commissioner is hereby authorized to charge [] \$150.00 (220) [X] \$300.00 (120) for the Government fee to Deposit Account No. 02-4800 and two extra copies of this brief are being filed herewith.

The Commissioner is hereby authorized to charge any appropriate fees under 37 C.F.R. §§1.16, 1.17, and 1.21 that may be required by this paper, and to credit any overpayment, to Deposit Account No. 02-4800. This paper is submitted in triplicate.



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I. **Real Party in Interest**

The present application is assigned to Lam Research Corporation.

II. **Related Appeals and Interferences**

The Appellants' legal representative, or assignee does not know of any other appeal or interferences which will affect or be directly affected by or have bearing on the Board's decision in the pending appeal.

III. **Status of Claims**

Claims 1-13 and 16-22 stand rejected in the December 8, 2000 final Official action.

IV. **Status of Amendments**

No amendments to the claims have been filed subsequent to the December 8, 2000 final Official Action.

V. **Summary of the Invention**

The present invention relates to a method of etching organic antireflective coatings (ARC's) in the fabrication of integrated circuits. Typically, the production of integrated circuits requires fabricating one or more networks of conductive pathways interconnecting the components to form systems and interconnecting the systems to form circuits. An important manufacturing step is the formation of a network of conducting pathways, or

interconnecting network, over a semiconducting substrate *via* photolithography and etching (collective these processes are referred to “patterning”). This is typically accomplished by coating a conductive, metallic layer, with a light sensitive coating, *i.e.*, a photoresist coating (“photoresist”). The photoresist is then exposed to actinic light through a mask which blocks the light in a pattern corresponding to the pattern desired for the conducting interconnecting network.

The photoresist coating is subsequently “developed,” that is, the parts of the photoresist coating which were exposed to the actinic light are selectively removed, thereby exposing the conductive surface below in a pattern corresponding to the openings in the mask. Usually the exposed metal layer is removed by plasma etching, but may also be removed by wet chemical etching, leaving the desired interconnecting network.

The demand in recent years for greater miniaturization of integrated circuits has led to increased circuit density, which requires shorter wavelength light such as deep ultraviolet(UV) to expose the photoresist. While the short wavelength light theoretically should yield exposures of high resolution, unfortunately it tends to reflect off the metallic layer back through the photoresist layer. This reflection sets up interference with the incoming light which reduces resolution. To solve this problem, an anti-reflective coating (ARC) is typically deposited on the metallic layer before the photoresist layer to reduce the unwanted reflection and consequential loss of resolution. The ARC’s widely used in the integrated circuit industry are polyimides although other **organic** anti-reflective material can be used.

After the photoresist has been exposed to UV and developed, the ARC must be removed by etching to uncover the underlying conductive, metallic layer or coating. The prior art teaches that this may be done by plasma etching. However, a system of etching agents and conditions must be used which effectively etch away the ARC but leave the photoresist relatively intact.

U.S. Patent No. 5,308,742 ("*Ta*") discloses a method of manufacturing an integrated circuit which includes a step of plasma etching a polyimide (i.e., **organic**) ARC using trifluoromethane (CHF_3) and elemental oxygen (O_2) with argon as a carrier gas. *Ta* asserts that CHF_3 promotes polymer formation while the argon acts as a sputter component which removes the polymer formed by CHF_3 . The sputter component travels primarily in a vertical direction so that the polymeric material on the sidewalls of the interconnecting network etched through the photoresist is not removed. This protects the sidewalls of the photoresist from lateral attack by oxygen. Purportedly, this method provides critical dimension control because it is selective for the ARC.

In *Ta*, oxygen appears to be the actual etching agent. Oxygen is an aggressive oxidizing agent and tends to be non-specific and detrimental to some solid state components. A milder oxidizing agent would offer greater selectivity between the ARC and the photoresist, and hence, an improvement over the process of *Ta*. Selectivity is important because the CHF_3 would not provide protection in the vertical direction if Ar sputtering removes CHF_3 deposited on top of the photoresist. Excessive erosion impairs

the photoresist's masking properties during the etching of the ARC and/or underlying conductive coating.

The present inventors discovered an improved process for selectively and effectively removing an ARC without the use of oxygen, thus, reducing degradation of the photoresist. In particular, Fig. 1a shows a perspective view of a greatly magnified section of a semiconductor composite chip **10** during manufacturing after the photoresist **12** has been exposed and developed, wherein the interconnecting network **14** forms the circuit pattern **15**. That is, the area of the conductive coating **16** corresponding to those portions of the photoresist not exposed, will become the network of conductive pathways interconnecting the components and systems. The conductive coating or layer covers a semiconductor base **17**. Fig. 1b, a cross sectional view corresponding to Fig. 1a, more clearly shows that after the photoresist is developed, part of the ARC **18** covers the bottom of the interconnecting network **14**. This part of the ARC must be removed before the underlying conductive coating **16** can be removed by etching.

In previous generations of integrated circuits, the conductive pathways formed by etching the conductive coating were relatively well separated so that some degradation of photoresist could generally be tolerated. However, in the present generation of integrated circuits, the conductive pathways are often so close together that even a small amount of degradation can be critical. Further, in order to achieve high resolution during exposure and development of deep UV photoresists, the thickness of the photoresist has been reduced

from around 12000Å to around 7000 to 8000Å. This leaves less photoresist to protect the underlying layers during etching of the ARC.

Fig. 2 is a schematic illustration of the results of removing the ARC with a system of agents containing O₂ ionized in a plasma generating chamber. For example, a system which employs a mixture of O₂ and N₂. While this system of agents containing O₂ effectively removes the ARC they also attack the photoresist **12** causing general thinning and degradation indicated as points **20** in Fig. 2. As illustrated in Fig. 2, the degradation reduces the precision of the interconnecting network **14** and can cause undesirable exposure of the underlying layers at other locations. Because the interconnecting network **14** controls what is etched away from the conductive coating, thinning and degradation can cause voids in the conducting pathways or faulty connections leading to errors in the function of the integrated circuit.

Fig. 3 is a schematic illustration of the results of removing the ARC with a system of agents of the present invention. Note that the photoresist **12** has been only minimally affected and retains its precision pattern. Therefore, the precision pattern will be transferred to the formation of conductive pathways in the next step when the exposed conductive coating **16** is etched away.

For the present process, the carrier gas is an inert, noble gas, preferably argon (Ar), although, other noble gases such as helium, neon, krypton, xenon or mixture thereof may be used. The source of chlorine preferably is chemically pure elemental chlorine (Cl₂). Alternatively, it is possible to use another chlorine containing gas such as HCl or BCl₃.

Similarly, while CHF_3 is the preferred source of fluorine, other fluorocarbon gases or combination of such gases may be used.

The present process can be carried out in an ECR or TCP™ reactor of the type described in the present application (see Figs. 4 and 5) or in any suitable reaction chamber of a plasma generator. The organic ARC can be on a semiconductor substrate such as a semiconductor wafer, flat panel display, etc. The process may be carried out within the following window:

Pressure	--	about 0.1 to about 500 millitorr
Temperature	--	about 0° to about 100° C
Cl_2 flow	--	about 2.5 to about 200 sccm
Inert gas flow	--	0 to about 200 sccm
Fluorine containing compound gas flow	--	about 5 to about 200 sccm

preferably it is carried out within the following window:

Pressure	--	about 1 to about 100 millitorr
Temperature	--	about 30° to about 80° C
Cl_2 flow	--	about 5 to about 60 sccm
Ar flow	--	about 5 to about 80 sccm
CHF_3 flow	--	about 5 to about 80 sccm

Process time varies with the composition and proportions of the reactants, and more importantly, the thickness of the organic ARC. The end point of the process, *i.e.*, when all

of the exposed ARC has been removed, can be determined by standard methods of this art using standard micro chip manufacturing equipment. For example, one may monitor an optical signal or the concentration of fluorine.

Accordingly, the present invention provides an improved process for etching an organic ARC on a metallic substrate by exposing the ARC to a system of **oxygen-free** etching agents in an ionized state in a reaction chamber of a plasma generating device, the system of etching agents including one or more fluorine-containing compounds, an inert carrier and chlorine. This process is particularly useful for preserving the critical dimensions of a photoresist while removing exposed areas of an organic ARC during the manufacturing of an integrated circuit. The fluorine-containing compound can be selected from the group consisting of CF_4 , CHF_3 , C_2F_6 , CH_2F_2 , SF_6 , C_nF_{n+4} . In a particular embodiment the fluorine-containing compound is CHF_3 and the inert carrier is argon.

VI. **The Issues**

The three issues presented by this appeal are (1) the rejection of Claims 1 - 4, 6 - 12, 17, 18 and 20 - 22 under 35 U.S.C. §103(a) as allegedly being unpatentable over Abraham (U.S. Patent No. 5,883,007) in view of Tsai (U.S. Patent No. 5,753,418); (2) the rejection of Claims 16 and 19 under 35 U.S.C. §103(a) as allegedly being unpatentable over Abraham in view of Tsai and further in view of Bariya (U.S. Patent No. 5,443,941; and (3) the rejection of Claims 5 and 13 under 35 U.S.C. §103(a) as allegedly being unpatentable over Abraham in view of Tsai the Examiner's "optimization" argument.

VII. Grouping of Claims

The claims do not stand or fall together for the following reasons.

Claim 1 sets forth a process for removing exposed areas of an organic ARC on a metallic layer, the exposed areas of the ARC having been exposed by previously etching a photoresist covering the ARC, the process comprising exposing the exposed areas of the ARC to an oxygen-free system of etching agents in an ionized state in a reaction chamber of a plasma generating device, the system of etching agents including one or more fluorine-containing compounds, chlorine and an optional inert carrier gas. Claim 2 sets forth that the one or more fluorine-containing compounds is selected from the group consisting of CF_4 , CHF_3 , C_2F_6 , CH_2F_2 , SF_6 , and C_nF_{n+4} . Claim 3 sets forth that the ARC is exposed by channels forming a circuit pattern previously etched in the photoresist covering the ARC. Claim 4 sets forth that the system of etching agents consists essentially of CHF_3 , Ar, and Cl_2 . Claim 5 sets forth that the process is carried out within the following window: Pressure — about 1 to about 100 millitorr; Temperature — about 30° to about 80° C; Cl_2 flow — about 5 to about 60 sccm; Ar flow — about 5 to about 80 sccm; CHF_3 flow — about 5 to about 80 sccm. Claim 6 sets forth that the ARC on the metallic layer has been used to prevent actinic light passing completely through the photoresist from being reflected from the metallic layer back through the photoresist during the exposure process. Claim 7 sets forth that the plasma generating device is evacuated to a pressure below 100 mTorr while etching the ARC with the etching agents. Claim 8 sets forth that the plasma generating device comprises an ECR reactor and the ARC is on a semiconductor substrate.

Claim 9 sets forth that the ARC is on a semiconductor wafer and Claim 10 sets forth that the plasma is generated adjacent a substrate including the ARC, the plasma generating device including a dielectric window facing the substrate and an antenna outside the reaction chamber, the antenna forming the plasma by inductively coupling radio frequency energy through the dielectric window and into the reaction chamber. Claim 16 sets forth that the organic ARC consists essentially of polyimide. Claim 17 sets forth that the system of etching agents is nitrogen-free. Claim 18 sets forth that the plasma generating device is evacuated to a pressure below 40 mTorr while etching the ARC with the etching agents.

Independent Claim 11 sets forth a method for substantially preserving a photoresist while removing exposed areas of an organic ARC during the manufacturing of an integrated circuit, comprising exposing the ARC to a system of etching agents in an ionized state in a reaction chamber of a plasma generating device, the system of etching agents including one or more fluorine-containing compounds, an inert carrier gas and chlorine. Claim 12 sets forth that the one or more fluorine-containing compounds is trifluoromethane and the inert carrier gas is argon. Claim 13 sets forth that the process is carried out within the following window: Pressure — about 1 to about 100 millitorr; Temperature —about 30° to about 80° C; Cl₂ flow — about 5 to about 60 sccm; Ar flow — about 5 to about 80 sccm; CHF₃ flow — about 5 to about 80 sccm. Claim 19 sets forth that the organic ARC consists essentially of polyimide. Claim 20 sets forth that the system of etching agents is nitrogen-free. Claim 21 sets forth that the plasma generating device is evacuated to a pressure below 40 mTorr while etching the ARC with the etching agents.

Claim 22 sets forth a process for etching a pattern of exposed areas of an organic ARC, comprising exposing the ARC to an oxygen-free system of etching agents in an ionized state in a reaction chamber of a plasma generating device, the system of etching agents including one or more fluorine-containing compounds, chlorine, and an inert carrier gas, wherein a photoresist layer forming the pattern of exposed area is disposed on the organic ARC, and wherein the organic ARC is selectively etched and the photoresist is substantially preserved such that lateral degradation of the photoresist layer forming the pattern of exposed areas is substantially prevented.

The final Official Action sets forth separate grounds of rejection of several groups of claims, i.e., the independent claims (Claims 1, 11 and 22) were rejected over the combination of Tsai and Abraham whereas Claims 16 and 19 were rejected over Tsai in view of Abraham and Bariya and Claims 5 and 13 were rejected over Tsai in view of Abraham and the Examiner's "optimization" argument. As explained below, the dependent claims set forth features not suggested in the applied references. As such, the claims do not stand or fall together.

VIII. Argument I

The Rejection

Claims 1 - 4, 6 - 12, 17, 18 and 20 - 22 stand rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Abraham (U.S. Patent No. 5,883,007) in view of Tsai

(U.S. Patent No. 5,753,418). The reasons for the rejection are set forth in paragraph 2, on pages 2-3 of the Official Action.

Legal Standard for §103 Rejection

This rejection should be reversed on the basis that:

- (1) The combination proposed in the Official Action renders the invention of Abraham unsatisfactory for its intended purpose;
- (2) The combination proposed in the Official Action improperly changes the principle of Abraham's invention;
- (3) The combination proposed in the Official Action is improper due to the lack of reasonable expectations of success; and
- (4) Tsai teaches away from the proposed combination.

As set forth in MPEP § 2142, to establish a *prima facie* case of obviousness, three basic criteria must be met:

- i. There must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings;
- ii. There must be a reasonable expectation of success; and
- iii. The prior art reference (or references when combined) must teach or suggest all the claim limitations.

Further, the teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).

Claims

Claim 1 sets forth a process for removing exposed areas of an organic ARC on a metallic layer, the exposed areas of the ARC having been exposed by previously etching a

photoresist covering the ARC, the process comprising exposing the exposed areas of the ARC to an oxygen-free system of etching agents in an ionized state in a reaction chamber of a plasma generating device, the system of etching agents including one or more fluorine-containing compounds, chlorine and an optional inert carrier gas. Claim 2 sets forth that the one or more fluorine-containing compounds is selected from the group consisting of CF_4 , CHF_3 , C_2F_6 , CH_2F_2 , SF_6 , and C_nF_{n+4} . Claim 3 sets forth that the ARC is exposed by channels forming a circuit pattern previously etched in the photoresist covering the ARC. Claim 4 sets forth that the system of etching agents consists essentially of CHF_3 , Ar, and Cl_2 . Claim 5 sets forth that the process is carried out within the following window: Pressure — about 1 to about 100 millitorr; Temperature — about 30° to about 80° C; Cl_2 flow — about 5 to about 60 sccm; Ar flow — about 5 to about 80 sccm; CHF_3 flow — about 5 to about 80 sccm. Claim 6 sets forth that the ARC on the metallic layer has been used to prevent actinic light passing completely through the photoresist from being reflected from the metallic layer back through the photoresist during the exposure process. Claim 7 sets forth that the plasma generating device is evacuated to a pressure below 100 mTorr while etching the ARC with the etching agents. Claim 8 sets forth that the plasma generating device comprises an ECR reactor and the ARC is on a semiconductor substrate. Claim 9 sets forth that the ARC is on a semiconductor wafer and Claim 10 sets forth that the plasma is generated adjacent a substrate including the ARC, the plasma generating device including a dielectric window facing the substrate and an antenna outside the reaction chamber, the antenna forming the plasma by inductively coupling radio frequency

energy through the dielectric window and into the reaction chamber. Claim 16 sets forth that the organic ARC consists essentially of polyimide. Claim 17 sets forth that the system of etching agents is nitrogen-free. Claim 18 sets forth that the plasma generating device is evacuated to a pressure below 40 mTorr while etching the ARC with the etching agents.

Independent Claim 11 sets forth a method for substantially preserving a photoresist while removing exposed areas of an organic ARC during the manufacturing of an integrated circuit, comprising exposing the ARC to a system of etching agents in an ionized state in a reaction chamber of a plasma generating device, the system of etching agents including one or more fluorine-containing compounds, an inert carrier gas and chlorine. Claim 12 sets forth that the one or more fluorine-containing compounds is trifluoromethane and the inert carrier gas is argon. Claim 13 sets forth that the process is carried out within the following window: Pressure — about 1 to about 100 millitorr; Temperature —about 30° to about 80° C; Cl₂ flow — about 5 to about 60 sccm; Ar flow — about 5 to about 80 sccm; CHF₃ flow — about 5 to about 80 sccm. Claim 19 sets forth that the organic ARC consists essentially of polyimide. Claim 20 sets forth that the system of etching agents is nitrogen-free. Claim 21 sets forth that the plasma generating device is evacuated to a pressure below 40 mTorr while etching the ARC with the etching agents.

Claim 22 sets forth a process for etching a pattern of exposed areas of an organic ARC, comprising exposing the ARC to an oxygen-free system of etching agents in an ionized state in a reaction chamber of a plasma generating device, the system of etching agents including one or more fluorine-containing compounds, chlorine, and an inert carrier

gas, wherein a photoresist layer forming the pattern of exposed area is disposed on the organic ARC, and wherein the organic ARC is selectively etched and the photoresist is substantially preserved such that lateral degradation of the photoresist layer forming the pattern of exposed areas is substantially prevented.

Examiner's Rationale

In the rejection, the Examiner proposes to modify Abraham by (1) substituting the organic ARC of Tsai for Abraham's inorganic Ti based ARC and (2) using Abraham's etching gas chemistry for the Ti based inorganic ARC to etch the substituted organic ARC.

Reasons for Reversal of Rejection

- (1) Lack of Motivation Because Proposed Modification Renders Abraham's Invention Unsatisfactory for its Intended Purpose

The rejection is improper because the modification of Abraham proposed by the Examiner renders the invention of Abraham unsatisfactory for its intended purpose. That is, if a proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there is no suggestion or motivation to make the proposed modification. *In re Gordon*, 733 F.2d 900, 221 USPQ 1125 (Fed. Cir. 1984). See MPEP 2143.01.

In the present case, Abraham discloses the use of a specific combination of etching agents for use with a TiN ARC to achieve desired selectivity with respect to an overlying photoresist and an underlying aluminum layer. Abraham's invention was intended to overcome deficiencies of prior etching techniques of etching TiN ARC layer materials (See

Column 7, Lines 47-64 of Abraham). Substitution of an organic ARC layer for the inorganic Ti based ARC layer of Abraham would defeat Abraham's intended purpose of providing an etchant chemistry with a high selectivity of the TiN ARC layer etch rate versus the photoresist etch rate. As such, it is submitted that the rejection is improper and should be reversed.

In the final Official Action, the Examiner only commented on Applicant's previously submitted arguments relating to the requirement for a reasonable expectation of success, above point (3). Because the Examiner has not addressed the present point (1), the rejection is not supported by all three of the basic criteria set forth in MPEP § 2142 . Namely, there is no suggestion or motivation to combine the reference teachings as proposed in the Official Action. As one of the basic criteria for a *prima facie* case of obviousness is lacking for the reasons explained above, the rejection is untenable and should be reversed.

(2) Lack of Motivation Based on Change of Principle of Abraham's Invention

The modification of Abraham proposed in the Official Action impermissibly changes the principle of operation of the invention of Abraham. That is, if the proposed modification or combination of the prior art would change the principle of operation of the prior art invention being modified, then the teachings of the references are not sufficient to render the claims *prima facie* obvious. *In re Ratti*, 270 F.2d 810, 123 USPQ 349 (CCPA 1959). See MPEP 2143.01.

In Abraham, the use of a specific combination of etching agents for etching Ti based inorganic anti-reflective coating layers is disclosed. As explained above, Abraham's invention sought to improve etch rate selectivity of the TiN ARC to the overlying photoresist and underlying aluminum layer. An organic ARC is a polymer based composition like Abraham's photoresist. Because substitution of an organic ARC layer for the inorganic Ti based ARC layer of Abraham would change the principle of operation of Abraham's invention, the rejection is improper since it is not supported by one of the three criteria required to establish a *prima facie* case of obviousness.

As mentioned above, in the final Official Action, the Examiner only commented on point (3). Because the Examiner has not addressed the present point (2), the rejection is not supported by all three of the basic criteria set forth in the MPEP. As one of the basic criteria for a *prima facie* case of obviousness is lacking for the reasons explained above, the rejection is improper and should be reversed.

(3) Lack of Reasonable Expectation of Success

Item (ii) of the three basic criteria required for a proper 35 U.S.C. §103 rejection relates to the showing of a reasonable expectation of success. As explained below, the combination proposed in the Official Action is improper because the Official Action has failed to establish the required reasonable expectation of success of using Abraham's etch chemistry for etching Tsai's organic ARC.

The etch chemistry employed by Abraham is specifically chosen based on its ability to selectively etch a Ti based inorganic ARC material vis-a-vis an overlying photoresist and

an underlying aluminum layer. Abraham, for example, discloses that the etch chemistry has an "exceptional ability to etch TiN ARC layer materials" (See Column 7, Lines 49-50 of Abraham). Abraham further discloses that the etchant achieves a desired etch rate selectivity of a TiN ARC to photoresist and TiN ARC to an underlying aluminum layer (See Column 7, Lines 46-51, Column 8, Lines 43-44 and 50-64 of Abraham).

Abraham's etch chemistry is chosen to achieve etching of Ti based inorganic ARC materials with minimum etching of polymer photoresist materials. Because an organic (i.e., polymer) ARC is similar in chemistry to a polymer photoresist, a person of ordinary skill in the art would not have had a reasonable expectation of success in etching an organic (polymer) ARC with the desired selectivity to a polymer photoresist. As pointed out earlier, the prior art establishes that organic and inorganic ARC materials are etched with completely different etchant gases. The Examiner has not identified any prior art reference establishing a reasonable expectation that an organic ARC can be successfully etched with a TiN etchant gas, nor has the Examiner established that the selectivity desired in Abraham could still be achieved when etching Tsai's organic ARC with Abraham's TiN etching gas. As such, the Official Action fails to establish the required reasonable expectation of success for the proposed combination of Abraham and Tsai.

In the Response to Arguments section of the Official Action, which appears in numbered paragraph 5, on page 5 of the Official Action, the Examiner contends that ". . . the reference of Abraham discloses that the first chemistry etching of CHF₃, Chlorine and an inert gas of Ar (col 6, lines 34-36) used to etch an inorganic ARC of TiN may also be

performed on **any** metallization- overlaying layer [paragraph 5 of the Official Action, emphasis in original].

The section of Abraham referred to above, however, reads as follows:

. . . the anti-reflective layer of the layer stack *is etched with a first chemistry*. . . this first chemistry etching may also be performed, *in certain layer stack structures*, on any metallization-overlaying layer, e.g., *adhesion layer, seed layer*, or the like. . . [Column 6, lines 8-17 of Abraham, emphasis added]

Abraham, however, then goes on to state:

. . . *this overlaying layer may be formed either of Ti, TiN, TiW or a material that is mainly titanium*. . . *the first chemistry for a TiN anti-reflective layer etch* may include any one of the group consisting of Cl₂/Ar/CHF₃, Cl₂/CHF₃/BCl₃, Cl₂/CHF₃, Cl₂/N₂, Cl₂/N₂/CHF₃, Cl₂/HCl/CHF₃, and Cl₂/N₂/BCl₃. [Column 6, lines 18-37 of Abraham, emphasis added]

The above passage of Abraham clearly conveys that, although the metallization-overlaying layer may in certain instances be a layer other than an ARC layer (e.g., an adhesion layer or a seed layer), the specific first chemistry disclosed by Abraham is intended for use with a TiN ARC. Accordingly, it is respectfully submitted that the Official Action fails to establish the required reasonable expectation of success.

(4) Tsai Teaches Away From the Proposed Combination

It is well established that a prior art reference must be considered in its entirety, i.e., as a whole, including portions that would lead away from the claimed invention. *W.L. Gore & Associates, Inc. v. Garlock, Inc.*, 721 F.2d 1540, 220 USPQ 303 (Fed. Cir. 1983), cert. denied, 469 U.S. 851 (1984). See MPEP §2141.02.

Tsai discloses using a different etch chemistry for etching an organic ARC than that employed by Abraham for etching a TiN ARC. Tsai, for example, discloses an etchant gas composition comprising carbon tetrafluoride and argon for etching the organic ARC (Column 6, Lines 52-54 of Tsai). Although it would not have been obvious to substitute Tsai's organic ARC for the TiN ARC of Abraham, such a substitution would also have necessitated substituting Tsai's organic ARC etchant gas in place of Abraham's etchant gas, thus teaching away from the claimed process. Because Tsai teaches away from the claimed process, the Examiner has therefore failed to establish a *prima facie* case of obviousness.

In view of the foregoing, it is submitted that the claimed process is clearly patentable over the combination of Abraham and Tsai.

IX. Argument II

The Rejection

Claims 16 and 19 stand rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Abraham in view of Tsai and further in view of Bariya. The reasons for the rejection are set forth in paragraph 3, on pages 3- 4 of the Official Action.

Claims

Claims 16 and 19 set forth that the organic ARC consists essentially of polyimide.

Examiner's Rationale

As set forth in the Official Action, Bariya is relied upon merely for its background mention of polyimide as an organic ARC. Bariya, however, fails to cure the

aforementioned deficiencies of Abraham and Tsai since the combination thereof fails to disclose the claimed process comprising exposing the exposed areas of an organic ARC to an oxygen-free system of etching agents in an ionized state in a reaction chamber of a plasma generating device, the system of etching agents including one or more fluorine-containing compounds, chlorine and an optional inert carrier gas. Accordingly, withdrawal of this ground of rejection is respectfully traversed.

Further, Bariya also teaches away from the combination proposed in the Official Action. In particular, Bariya discloses using a different etch chemistry than that employed by Abraham. Bariya, for example, discloses an oxygen plasma for etching the organic ARC (Column 5, Lines 9-12 of Bariya). Although it would not have been obvious to substitute Bariya's organic ARC for the TiN ARC of Abraham, such a substitution would also have necessitated substituting Bariya's organic ARC etchant gas for Abraham's TiN ARC etchant gas, thus teaching away from the claimed process. Because Bariya teaches away from the claimed process, the Examiner has failed to establish a *prima facie* case of obviousness.

X. Argument III

Ground of Rejection

Claims 5 and 13 stand rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Abraham in view of Tsai and further in view of the Examiner's

“optimization” argument. The reasons for the rejection are set forth in paragraph 4, on page 4 of the Official Action. The rejection should be reversed for the following reasons.

Legal Standard for §103 Rejection

Obviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either in the references themselves or in the knowledge generally available to one of ordinary skill in the art. *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988); *In re Jones*, 958 F.2d 347, 21 USPQ2d 1941 (Fed. Cir. 1992). The mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination. *In re Mills*, 916 F.2d 680, 16 USPQ2d 1430 (Fed. Cir. 1990). See MPEP 2143.01.

Claims

Claims 5 and 13 set forth that the process is carried out within the following window: Pressure — about 1 to about 100 millitorr; Temperature —about 30° to about 80° C; Cl₂ flow — about 5 to about 60 sccm; Ar flow — about 5 to about 80 sccm; CHF₃ flow — about 5 to about 80 sccm.

Examiner's Rationale

In the final Official Action, the Examiner took the position that "one skilled in the art would have found it obvious to employ any of a variety of gas flow rates including those claimed by the applicant because etchant flow rate is a well known variable in the plasma

etching art which is known to effect [sic] the plasma etching process" and that "the selection of particular flow rates would simply involve routine experimentation".

Reasons for Reversal of Rejection

Tsai, the primary reference relied on by the Examiner discloses etching of an organic ARC layer 16 using a chamber reactor pressure of 800 to 1800 mtorr, a substrate temperature of 0 to 20 °C, a CF₄ flow rate of 40 to 120 sccm and an Ar flow rate of 400 to 800 sccm (column 6, lines 44-47 and column 7, lines 41-65 of Tsai). Comparing these process conditions to those set forth in Claims 5 and 13 reveals that Tsai's pressure of 800-1800 mtorr is far higher than the claimed pressure of about 1 to 100 mtorr, Tsai's temperature of 0-20 °C is lower than the claimed 30 to 80 °C, Tsai's CF₄ is not suggestive of the claimed Cl₂, and Tsai's Ar flow rate of 400 to 800 sccm is far higher than the claimed about 5 to 80 sccm. Contrary to the Examiner's argument, "optimization" of Tsai's process will not result in the claimed process since there is no overlap between Tsai's etch gas chemistry or reactor conditions vis-a-vis the claimed parameters.

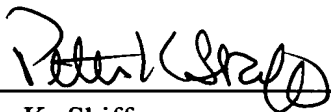
In addition to the above distinctions, as explained in Argument I above, it would not have been obvious to substitute an organic ARC for Abraham's inorganic ARC because: (1) the result would render Abraham's invention unsuitable for its intended purpose; (2) the result would improperly change the principle of Abraham's invention; (3) there is no reasonable expectation of success; and (4) the result goes against the teachings of Tsai. However, if Abraham's ARC was replaced with Tsai's organic ARC, one of ordinary skill would have also replaced Abraham's etchant gas with Tsai's etchant gas in which case (1)

Tsai's etchant gas would not suggest the etchant gas used in the claimed process and (2) optimization of the flow rates thereof would not suggest the features of Claims 5 and 13.

XI. Conclusion

Applicants submit that it has been established that the differences between the claimed subject matter and the prior art are such that the claimed subject matter, as a whole, would not have been obvious at the time the invention was made to a person having ordinary skill in the art. In view of the foregoing, Applicants submit that the prior art rejections are untenable and should be reversed.

Respectfully submitted,
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APPENDIX

Appealed Claims

1. A process for removing exposed areas of an organic ARC on a metallic layer, the exposed areas of the ARC having been exposed by previously etching a photoresist covering the ARC, the process comprising exposing the exposed areas of the ARC to an oxygen-free system of etching agents in an ionized state in a reaction chamber of a plasma generating device, the system of etching agents including one or more fluorine-containing compounds, chlorine and an optional inert carrier gas.

2. The process of Claim 1, wherein the one or more fluorine-containing compounds is selected from the group consisting of CF_4 , CHF_3 , C_2F_6 , CH_2F_2 , SF_6 , and C_nF_{n+4} .

3. The process of Claim 1, wherein the ARC is exposed by channels forming a circuit pattern previously etched in the photoresist covering the ARC.

4. The process of Claim 1, wherein the system of etching agents consists essentially of CHF_3 , Ar, and Cl_2 .

5. The process of Claim 4, carried out within the following window:

Pressure -- about 1 to about 100 millitorr

Temperature	--	about 30° to about 80° C
Cl ₂ flow	--	about 5 to about 60 sccm
Ar flow	--	about 5 to about 80 sccm
CHF ₃ flow	--	about 5 to about 80 sccm.

6. The process of Claim 3, wherein the ARC on the metallic layer has been used to prevent actinic light passing completely through the photoresist from being reflected from the metallic layer back through the photoresist during the exposure process.

7. The process of Claim 1, wherein the plasma generating device is evacuated to a pressure below 100 mTorr while etching the ARC with the etching agents.

8. The process of Claim 1, wherein the plasma generating device comprises an ECR reactor and the ARC is on a semiconductor substrate.

9. The process of Claim 1, wherein the ARC is on a semiconductor wafer.

10. The process of Claim 1, wherein the plasma is generated adjacent a substrate including the ARC, the plasma generating device including a dielectric window facing the substrate and an antenna outside the reaction chamber, the antenna forming the plasma by inductively coupling radio frequency energy through the dielectric window and into the reaction chamber.

11. A method for substantially preserving a photoresist while removing exposed areas of an organic ARC during the manufacturing of an integrated circuit, comprising exposing the ARC to a system of etching agents in an ionized state in a reaction chamber of a plasma generating device, the system of etching agents including one or more fluorine-containing compounds, an inert carrier gas and chlorine.

12. The method of Claim 11, wherein the one or more fluorine-containing compounds is trifluoromethane and the inert carrier gas is argon.

13. The method of Claim 12, carried out within the following window

Pressure	--	about 1 to about 100 millitorr
Temperature	--	about 30° to about 80° C
Cl ₂ flow	--	about 5 to about 60 sccm
Ar flow	--	about 5 to about 80 sccm
CHF ₃ flow	--	about 5 to about 80 sccm.

14. Canceled

15. Canceled

16. The method of Claim 1, wherein the organic ARC consists essentially of polyimide.

17. The method of Claim 1, wherein the system of etching agents is nitrogen-free.
18. The method of Claim 1, wherein the plasma generating device is evacuated to a pressure below 40 mTorr while etching the ARC with the etching agents.
19. The method of Claim 11, wherein the organic ARC consists essentially of polyimide.
20. The method of Claim 11, wherein the system of etching agents is nitrogen-free.
21. The method of Claim 11, wherein the plasma generating device is evacuated to a pressure below 40 mTorr while etching the ARC with the etching agents.
22. A process for etching a pattern of exposed areas of an organic ARC, comprising exposing the ARC to an oxygen-free system of etching agents in an ionized state in a reaction chamber of a plasma generating device, the system of etching agents including one or more fluorine-containing compounds, chlorine, and an inert carrier gas, wherein a photoresist layer forming the pattern of exposed area is disposed on the organic ARC, and wherein the organic ARC is selectively etched and the photoresist is substantially preserved such that lateral degradation of the photoresist layer forming the pattern of exposed areas is substantially prevented.